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THE GRADUATE RECORD EXAMINATION (GRE)
AS A PREDICTOR OF SUCCESS AT THE
NAVAL POSTGRADUATE SCHOOL:
A VALIDATION TEST

by

Ronna C. Neil

June 1989

Thesis Advisor: Roger D. Evered

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The thesis contributes to the NPS's on-going three-year study of the value of the Graduate Record Examination in the School's admissions process.

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The Graduate Record Examination (GRE) as a Predictor of Success at the Naval Postgraduate School: A Validation Study

by

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Lieutenant Commander, United States Navy
B.A., Florida State University, 1976

Submitted in partial fulfillment of the requirements for the degree of

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The thesis contributes to the NPS's on-going three-year study of the value of the Graduate Record Examination in the School's admissions process.

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I. INTRODUCTION

The following is an excerpt from a Chief of Naval Information release dated 13 September 1985:

> Monterey, Calif. (NNS)--The Naval Postgraduate School here will study the relationship between Graduate Record Examination (GRE) test scores and a graduate student's performance.
>
> Starting April 1986 and running for three years the Naval Postgraduate School will administer the GRE General Test to all its entering students to determine if GRE scores provide better uniformity in judging intellectual capability and whether there is a correlation between test scores and a student's success in graduate school.
>
> The GRE will be administered within two weeks of the student's arrival here at the government's expense....
>
> This study will not affect applications to the Naval Postgraduate Program, which will be processed as before. The annual Graduate Education Selection Board will continue to use a three digit academic profile code (APC) to determine whether an officer meets the minimum academic prerequisites to be considered for selection to a fully-funded graduate education. The selections will continue to be based on consideration of professional performance and APC scores.
>
> NAVNEWS 005/85
> [Ref. 1]

The intention of this thesis is to examine the relationship between Graduate Record Examination scores and student success at the Naval Postgraduate School and to confirm, or otherwise, findings in previous studies.

A. BACKGROUND

In this period of evertightening defense dollars and threats of Congressional cuts to officer manning levels, it is increasingly important that the Navy use the best available methods of selecting students for advanced education.

This would ensure that those individuals who would not succeed in graduate institutions are not sent to the Naval Postgraduate School when they could better serve the Navy elsewhere.

Not only is the cost of maintaining a graduate institution considerable, but there are significant opportunity costs to the Navy in having officers not performing their regular military duties. To the individual officer not suited to graduate education, the cost of attending school is also high; dropping out, never completing a thesis, failing to get a degree, or failing to get a P-code have serious negative impacts on an officer's career progression and potential for continuation to retirement.

On 15 October 1984 the Graduate Education Review Group (GERG) met to review the status of graduate education in the Navy. On 17 October the Graduate Education Review Board (GERB) met to consider the issues arising from the preceding meeting. [Ref. 2] Appendix A lists the participants.

Action items emanating from these meetings included the following:

> NPS/OP-01 explore the use of indices to measure the quality and potential of entering graduate students. National norms such as the Graduate Record Examination should be considered. These factors could ultimately provide useful broad-based correlations on subsequent student academic performance and provide useful quality control data.... [Ref. 2]

Currently, entry into Navy-sponsored graduate education is based on professional military performance and the Academic Profile Code (APC).

> This is a numerical three-digit code assigned by the Postgraduate School to all commissioned officers after a year of commissioning, and it reflects the officer's undergraduate performance with respect to his/her overall grade point average (first digit), mathematics exposure (second digit), and physics exposure (third digit). Each offered curriculum has associated with it a threshold criterion based on an APC. [Ref. 3]

However, the Academic Profile Code has several deficiencies:

- It doesn't completely allow for the differences in academic standards and grading standards that exist between various colleges and universities.
- It has a bias toward engineering, whereas many of the offered curricula are non-technical in nature.
- Verbal and written skills are not measured. [Ref. 3]

Through further correspondence to the Chief of Naval Operations (CNO), the Superintendent, Naval Postgraduate School amplified this point by explaining,

> The existing procedure for assessing an individual's undergraduate academic transcript and then assigning an academic profile code (APC) is a useful but crude system for speeding up the deliberations of the postgraduate education selection board, for it relieves the board members from having to make academic assessments. The deficiencies of the APC system regarding inconsistencies among grading practices at various schools is difficult to overcome[1]....The APC contains inherent limitations, for it

---

[1]"Academic standards vary significantly over...schools. NPS has experienced an officer with a B.A. in math that had never taken a calculus course (nor was he capable of mastering calculus as it turned out). The NPS 'APC' system is a process which reduces an entire undergraduate transcript to three digits....Clearly the APC is a very, very crude instrument but it is more efficient than

> is merely an assessment of past academic records and not an examination of knowledge.
>
> The cost to the Naval Postgraduate School of performing the APC transcript evaluations for one year group is approximately $65K per year, or about $9 per officer accession....The GRE is recognized by American academic standards as the best nationally based testing instrument and most other graduate schools require it as a condition of admission. GRE data would allow for the tracking of academic quality over time....From an academic point of view the best time to administer the GRE would be just before the individual graduates from college. This timing would capture knowledge of the preceding four years of school work and would serve as a measure of intelligence. It would require about 7000 examinations a year at a cost of about $25 apiece...for a total funding requirement of about $175K.
>
> ...there is already a ten year investment in the APC program which should be not be abandoned. [Ref. 5]

However, implementing a requirement for all commissioned officers to take the Graduate Record Examination in their last year of college or during Officer Candidate School (OCS) would "ensure a standard of uniformity that does not now exist...." [Ref. 3]

Convinced that the method chosen to select officers to receive "valuable graduate education must be as valid and meaningful as possible" [Ref. 6], the Chief of Naval Operations formally tasked the Naval Postgraduate School to conduct a three-year study to determine "the necessary

---

expecting the 40-60 officers convened for the postgraduate selection board to be able to decipher transcripts from 500 plus different schools and systems. However the implicit assumption in the APC system is that all schools are of the same quality! A recent National Institute of Education study (December 1984) notes, 'Graduate schools do not treat college diplomas as equivalent although it is still considered impolite to talk openly about the differences in standards among colleges--for which reasons standardized tests are used in the graduate school admissions process.'" [Ref. 4]

correlations between various possible predictors and performance." [Ref. 6] He further tasked the Superintendent to "brief the Graduate Education Review Group (GERG) annually on the status of the study and make a final recommendation to the GERG in October 1989." [Ref. 6] To support this study, he also directed students entering the Naval Postgraduate School "starting in April 1986 and beyond" [Ref. 6] to take the Graduate Record Examination.

Funding to cover the cost of administering the Graduate Record Examination at the outset of the study was thought to be the responsibility of the Navy, in particular, the Naval Postgraduate School. [Ref. 7] However in April 1987 the Defense Activity for Non-Traditional Education Support (DANTES) advised the Navy that "both the GRE and GMAT are funded by DANTES for administration to military personnel." [Ref. 8]

B. PURPOSE

This thesis has the following objectives:

- To contribute to the body of knowledge in the Naval Postgraduate School's ongoing three-year study of the Graduate Record Examination by determining whether or not the Graduate Record Examination predicts student success at the Naval Postgraduate School better than the currently used Academic Profile Code.
- To determine whether or not results obtained in earlier studies during this time frame can be validated using more current data.
- To compare the predictive value of the Graduate Record Examination for the different Naval Postgraduate School divisions--Policy and Information Sciences Division (05) and Sciences and Engineering Division (06).

C. METHODOLOGY

Because the Graduate Record Examination is now administered to all new students within a few weeks of their arrival at the Naval Postgraduate School, a data file of Graduate Record Examination scores from the Educational Testing Service could be compiled for all NPS students. Additional data from registrar and admissions files were collected on Academic Profile Codes, grades and student demographics. Statistical analysis of these data consists of a series of correlations as a standardized means of measuring associations between variables as well as regression analysis to determine the relationship between these various predictors and success at the Naval Postgraduate School. The statistical package used in this analysis is SAS, a trademark of SAS Institute Incorporated.

D. LIMITATIONS

This study is limited to U.S. Navy students who have already been selected and are currently attending or have graduated from the Naval Postgraduate School during the three-year Graduate Record Examination test period (April 1986-April 1989). Excluded were students from other branches of military service, international students, continuing education students, aviation safety students and part-time students assigned as Naval Postgraduate School staff. The study is further restricted to students who have completed exactly six academic quarters. This allows the

most equitable evaluation of students who have graduated from 18-month curricula as well as students who have completed the majority of a long curriculum.

In order to maintain consistency with prior studies during the Graduate Record Examination test period, students 40 and older were also eliminated. [Ref. 9]

II. PRIOR RESEARCH

Worthy of note as part of the three-year Naval Postgraduate School study is the June 1988 thesis conducted by Transki. In her literature review she summarizes previous studies of the Graduate Record Examination as a predictor of academic success at the Naval Postgraduate School from the 1960's to the present. It is recapitulated here.

A. 1960'S

1. Martz/Rushin

In 1962, Martz and Rushin produced the first of this series of theses examining the use of the Graduate Record Examination in the management curriculum. They considered the Graduate Record Examination, the California Analogies and Reasoning Test and the Navy Officer Classification Battery. After performing a number of statistical tests on data collected from the 1962 class (N = 94), they determined the Graduate Record Examination was the most statistically significant of the instruments examined. Their recommendation to use the Graduate Record Examination was couched in hesitant terms, however. Specifically, the Graduate Record Examination (aptitude) produced by the Educational Testing Service was found to be the best of the three instruments considered but is encumbered with certain restrictions that reduce the adaptability for Navy-wide testing as proposed in this study. The Graduate Record Examination is recommended as a highly effective tool for faculty-student counselling and guidance programs....

2. Kauder/Ebert

The second in the Management School theses series was written in 1963 by Kauder and Ebert. They studied the Navy Officer Classification Battery, the Graduate Record Examination and the Navy Officer Qualification Test. Statistical analysis was conducted on the class of 1963 (N = 94) with a statistical reliability of 95 percent. Kauder and Ebert concluded that the Graduate Record Examination had a very high validity and was, in fact, the best predictor of the three options. Based upon this conclusion, they recommended the Graduate Record Examination be used as the admission criterion....

3. Dreese/Russel

Finally, in 1964, Dreese and Russel examined the Graduate Record Examination, the Structured-Objective Rorschach Test-Sort, the Allport-Vernon-Lindzey Study of Values and a local questionnaire of motivation. They studied the management class of 1964 (N = 99). After extensive statistical correlation, they concluded that the Graduate Record Examination was an "excellent predictor of academic performance"...and should be administered to management candidates....

B. 1970'S

1. Cook

Worthy of mention is a thesis conducted in 1974 by Cook. This paper is concerned with the merits of the Graduate Record Examination, the Strong Vocational Interest Blank, a biographical questionnaire and undergraduate academic performance in determining success in the Communications Management curriculum (N = 42). This thesis, unlike the previous studies, considered not only psychological and testing instruments, but also the Educational Potential Code. The Educational Potential Code was an earlier version of today's Academic Profile Code. His conclusion did not specify which of these instruments was best, but instead built a series of tables with combinations of indicators to assist in student selection....

2. Elster

In August of 1974, Professor R.S. Elster prepared a letter to the Naval Personnel Research and Development Center offering a manual to be used by the graduate education selection boards. It contained prediction tables for four curricula. These tables were based on such factors as undergraduate grades, undergraduate university "school scores," age, foreign language ability, whether or not the officer was a Naval Academy graduate, rank, Graduate Record Examination scores and whether or not the officer had an engineering degree. The tables were to be used after the selection boards had considered professional military performance and undergraduate academic performance....

C. 1980'S

1. Michealson/Phillips/Jeong/Lee

In a 1985 class project, Michealson, Phillips, Jeong and Lee attempted specifically to look at correlations between final grades and the Academic Profile Code, as well as final grades and undergraduate grade point averages. They studied the December 1984 graduating class (N = 52). They found the highest correlations among those students who were Naval Academy graduates and those students who were in technical curricula. One would expect this result since the Academic Profile Code

measures not only the undergraduate grade point average, but also exposure to technical curricula....

2. Blatt

Blatt used an analysis of variance technique to look at students in the Operations Analysis curriculum (N = 159). He was interested in student performance as measured by the Academic Profile Code, time since undergraduate studies, which undergraduate college the student attended, what kind of degree the student earned, what the student's military designator was and whether or not the student had attended the math refresher training before starting the Operations Analysis courses. He found the undergraduate grade point average score of the Academic Profile Code to be a significant variable. The math and science codes of the Academic Profile Code, however, were not meaningful. Other factors he found to be significant were the time away from undergraduate studies, military designator and type of college degree....

3. Barr/Howard

Perhaps the most definitive and useful study done to date was accomplished by Barr and Howard in 1987. They took a preliminary look at data collected from the three-year study begun in April 1986. Their report encompassed 320 records of students who had taken the Graduate Record Examination and had completed at least three quarters of study at the Naval Postgraduate School.

Their conclusions were five-fold:

1. Using the Graduate Record Examination in conjunction with the other currently used admission criteria will significantly improve the prediction.
2. The best selection of variables is the verbal and quantitative scores of the Graduate Record Examination used with the undergraduate grade point average score of the Academic Profile Code and the student's age.
3. The math and science scores of the Academic Profile Code are not significantly useful in prediction. They are, however, still an important part of the admission criteria.
4. Predictor significance varies over curricula.
5. Distinguishing poor performers is difficult using the variables available.... [Ref. 9:pp. 4-6]

As the fourth and most recent study conducted in the 1980's, Transki's thesis

...examines a sample of 198 students who took the Graduate Record Examination after arrival at the school and who have completed six quarters of study. The results indicate that the Graduate Record Examination is a much stronger predictor than the currently used undergraduate

> measures (Academic Profile Code). When the Graduate Record Examination scores are combined with undergraduate grade point average and the officer's age, an excellent predictor is developed. The thesis contains, in addition to descriptive information and regression results, a prediction equation which may be used by Navy selection committees in determining whether or not an officer will succeed at the Naval Postgraduate School. [Ref. 9:p. iii]

In addition, two studies from the 1970's were jointly conducted by Naval Postgraduate School associate professors Senger and Elster in 1974 and 1975. These technical reports reviewed a number of research efforts concerned with predicting the academic performance of graduate students. Concentrating on academic aptitude predictors (Graduate Record Examination, Miller Analogies Test and undergraduate grade point average), the report tabulated correlational statistics used at various universities to analyze the relationship between these predictors and the following output measures: graduate academic performance; faculty rating of graduate students; and completion of degree requirements. Findings for the most part showed these predictors performed only modestly in predicting academic performance.

However, in the Naval Postgraduate School studies reviewed, in which the GRE was used as a predictor, higher validity coefficients were found. Correlations between grades and GRE (verbal) were .51, .44 and .43, with GRE (quantitative) correlations being even higher, .73, .70 and .65 for studies conducted in 1966, 1967 and 1969, respectively.

In their review of non-intellectual factors as predictors of academic performance, Senger and Elster report that the selectivity of the college may be a useful environmental factor in identifying the meaningfulness of various undergraduate grade point averages. [Ref. 10:p. 16] Further review of non-intellectual factors in the areas of motivation and interest, however, show relatively low predictive results.

Senger and Elster conclude with the observation that

> The necessity to choose from among the applicants to graduate schools persists, however, and though the relationships between single predictors and criteria are not particularly strong, they can be useful for decision making.... [Ref. 11:pp. 18-19]

III. DATA

To facilitate understanding, descriptions of the data used in this study are presented below. They can be divided into two types--predictors of graduate success and criteria for determining graduate success at the Naval Postgraduate School.

A. PREDICTORS

1. Academic Profile Code

Generated by the Naval Postgraduate School, the Academic Profile Code is a three-digit numerical summary of an officer's undergraduate performance.

The first digit, generated from Table 1 below, reflects an officer's undergraduate grade point average. Calculations include failures and repeated courses. [Ref. 12:p. 17]

The second digit represents an officer's exposure to mathematics. It is calculated based on Table 2 below. [Ref. 12:p. 17]

The third and final digit of the Academic Profile Code represents an officer's exposure to science and technical fields. It is calculated using the criteria in Table 3. [Ref. 12:p. 17]

TABLE 1

UNDERGRADUATE QUALITY POINT RATING (QPR)

QPR CODE
(1st APC Digit)

Code #	Grade	QPR Range
0	A-/A	3.60--4.00
1	B+	3.20--3.59
2	B-/B	2.60--3.19
3	C+	2.20--2.59
4	C	1.90--2.19
5	Below C	0.00--1.89

Source: JAN 88 Admissions Office Handout

TABLE 2

UNDERGRADUATE MATH CODE

MATH CODE
(2nd APC Digit)

Code #	Calculus-Related Math Courses
0	Significant post-calculus math with a B average. (Math major or strong math minor)
1	Two or more calculus courses with a B+ average.
2	Two or more calculus courses with a C+ average.
3	One calculus course with a C grade or better.
4	Two or more pre-calculus courses with B average or better.
5	At least one pre-calculus course with a C grade or better.
6	No college-level pre-calculus course with a C grade or better.

Source: JAN 88 Admissions Office Handout

TABLE 3

UNDERGRADUATE TECHNICAL CODE

TECHNICAL CODE
(3rd APC Digit)

Code	Physics (Calculus-Based)	Significant Upper-Division Course Coverage in a Pertinent Engineering or Physical Science Discipline
0	----------	B+ average
1	----------	C+ average
2	Complete sequence completed with a B+ average	
3	Complete sequence completed with a C+ average	
4	At least one course with C grade	
5	None	

Source: JAN 88 Admissions Office Handout

For example,

An APC of 221 indicates a total grade average for all college courses in the interval 2.60--3.19, a complete sequence in calculus-of-one-variable with a C+ or B average, and a major in physics or pertinent engineering area with upper-division courses with a C+ or B average. [Ref. 12:p. 17]

2. Graduate Record Examination

a. The Test

The GRE General Test measures and yields separate scores for the general verbal, quantitative, and analytical abilities students should have acquired to be successful at the graduate level of education....

The verbal measure (two 30-minute sections) employs four types of questions: antonyms, analogies, sentence completions, and reading comprehension sets....

The quantitative measure (two sections) employs three types of questions--discrete quantitative questions, data interpretation questions, and quantitative comparison questions--to test basic mathematical skills, understanding of elementary mathematical concepts, and ability to reason quantitatively and solve problems in a quantitative setting....

The analytical measure (two sections) employs two types of questions--analytical reasoning and logical reasoning.... [Ref. 13:p. 7]

b. Scores

Scores on the Graduate Record Examinations are reported as three-digit scaled scores with the third digit always zero. Thus, a reported score of 530 represents all the scaled scores from 525.00 through 534.99.

Since October 1, 1981, the maximum obtainable verbal, quantitative, or analytical ability score on the GRE General (Aptitude) Test has been 800. The minimum score is 200.

...maximum and minimum have no absolute significance. That is, for example, an 800 score does not indicate complete knowledge nor does a 200 score indicate no knowledge at all. Nor does any score indicate what fraction of a given body of knowledge a student has mastered.... [Ref. 13:p. 31]

c. Graduate Record Examination Scores as Admissions Criteria

Scores in the GRE General Test have certain advantages over the other elements to be considered because, unlike undergraduate records, which are based on different courses and instructors for each applicant, the GRE General Test demands the same or equivalent tasks of everyone. This standardization permits comparison of one applicant to a graduate school with other applicants for the same program at that institution as well as with everyone else who took the test. [Ref. 13:p. 10]

However, GRE scores should never be the sole basis for an admission decision.

3. Student Demographics

To protect the privacy of the individuals involved in this study, names are not included in the data. However, the following demographic factors are included:

- sex,
- date of birth,
- rank,
- designator,
- type of undergraduate degree,
- curriculum at NPS,
- date of undergraduate degree,
- date of GRE administration,
- date reported to NPS,
- age at time of GRE administration (computed)[2],

---

[2]Age at time of GRE administration was computed by subtracting date of birth from the date of the examination.

- time since undergraduate degree and GRE administration (computed)[3].

B. CRITERION

The criteria used to measure academic success can take several forms. Student self-ratings, faculty ratings of students other than by grades, quality of thesis, completion of degree requirements, involvement in campus affairs, and grade point average are some of the possible indicators of graduate school success. Each of these criteria has its advantages and disadvantages.

The criterion chosen for use in this study is the grade point average because of its relative objectivity, ready availability, and ease in quantifying and interpreting.

1. Standardized Quality Point Rating (ZQPR)

The Naval Postgraduate School's label for grade point average is "Quality Point Rating" or "QPR." The Quality Point Rating is calculated based on the values indicated in Table 4. [Ref. 12:p. 14]

> When the quarter-hour credit of a course is multiplied by the point value of the student's grade, a quality point value for the student's work in the course is obtained. The sum of the quality points for all courses divided by the sum of the quarter-hour credit of these courses gives a weighted numerical evaluation of the student's performance,...(QPR). A student achieving a QPR of 3.0 has maintained a B average in all courses undertaken with a proper weight assigned for course hours. [Ref. 12:p. 14]

---

[3]Time since undergraduate degree was computed by subtracting date of undergraduate degree from the date of the examination.

TABLE 4

QUALITY POINT RATING COMPUTATION

Grade	Points
A	4
A-	3.7
B+	3.3
B	3
B-	2.7
C+	2.3
C	2
C-	1.7
D+	1.3
D	1
X	0

To successfully complete the requirements for a Master's Degree at the Naval Postgraduate School a student must attain "a quality point rating of at least 3.00 in all graduate courses in the curriculum, and either 2.50 in the remaining courses or 2.75 in all courses in the curriculum." [Ref. 12:p. 7]

Because grading standards vary even within institutions, an attempt was made in this study to standardize Quality Point Ratings with respect to the various grading practices among Naval Postgraduate School departments. Standardized scores were arrived at by dividing students' cumulative graduate Quality Point Ratings by a department factor. The individual department factors were calculated by dividing the department's QPR average by the entire school's QPR average of 3.47. [Ref. 14] Table 5 shows the computed department factors.

TABLE 5

DEPARTMENT STANDARDIZING FACTORS

Code	Department	Factor
52	Computer Science	1.029
53	Mathematics	.994
54	Administrative Sciences	.983
55	Operations Research	.997
56	National Security Affairs	1.069
61	Physics (relatively tough grading)	.963
62	Electrical & Computer Engineering	.986
63	Meteorology	.994
67	Aeronautics	1.026
68	Oceanography	.986
69	Mechanical Engineering	1.006
71	Antisubmarine Warfare Academic Group (relatively easy grading)	1.153
72	Electronic Warfare Academic Group	.986
73	Space Systems Academic Group	.991
74	Command, Control & Communications Academic Group	1.012
	NPS--All Departments	1.000

Standardizing grades using the above department factors makes the use of cumulative graduate Quality Point Ratings a better comparative measure of success at the Naval Postgraduate School.

IV. ANALYSIS

In order to examine the relationship between Graduate Record Examination scores and student success at the Naval Postgraduate School and to maintain consistency with prior studies during the April 1, 1986 to April 1, 1989 test period, this thesis attempts to replicate as closely as possible the procedures of the June 1988 Transki study.

As explained in Chapter I, this study is limited to U.S. Navy students who have completed exactly six academic quarters at the Naval Postgraduate School. This allows the most equitable evaluation of students who have graduated from 18-month curricula as well as students who have completed the majority of a long curriculum.

The Transki study analyzed the data associated with the 198 students who had completed exactly six quarters in December 1987. Similarly, this study analyzes those students who have subsequently completed exactly six quarters at the Naval Postgraduate School. Data available for analysis include 95 March 1988 sixth-quarter students and 102 June 1988 sixth-quarter students for a total of 197 students. This is one student less than in the initial study.

A. DESCRIPTIVE STATISTICS

In this analysis, variables have been given the same labels as in previous research:

Academic Profile Code	
Undergraduate Quality Point Rating Code	APC1
Math Code	APC2
Technical Code	APC3
Graduate Record Examination	
Verbal	VB
Quantitative	QT
Analytical	AN
Other Variables	
Age at time of exam (in years)	AGE
Time since undergraduate degree (in years)	T
Standardized Graduate Quality Point Rating	ZQPR
Predicted Graduate Quality Point Rating	QPR*

[Ref. 9]

Table 6 shows the mean, minimum and maximum values for the continuous variables using the variable labels just identified.

TABLE 6

CONTINUOUS VARIABLES--SIXTH-QUARTER DATA
(MAR 88/JUN 88)

VARIABLE	N	MEAN	MINIMUM	MAXIMUM	STD DEV
AGE	197	30.99	25	39	3.36
T	193	7.79	2	16	2.98
VB	197	549.64	310	800	91.45
QT	197	629.09	370	800	98.26
AN	197	573.76	260	800	105.42
APC1	196	1.94	0	4	0.86
APC2	196	2.18	0	6	1.04
APC3	196	3.24	0	5	1.54
ZQPR	197	3.52	2.45	4.48	0.37

Table 7 shows the relative percentages of females and males in the sample.

TABLE 7

SEX--SIXTH-QUARTER DATA
(MAR 88/JUN 88)

SX	FREQUENCY	PERCENT
F	36	18.3
M	161	81.7

Table 8 shows the breakout of students by rank.

TABLE 8

RANK--SIXTH-QUARTER DATA
(MAR 88/JUN 88)

Rank	Frequency	Percent
Lieutenant (junior grade)	1	.5
Lieutenant	40	20.3
Lieutenant Commander	151	76.6
Commander	5	2.5

Table 9 shows the breakout of students by officer category.

TABLE 9

OFFICER CATEGORY--SIXTH-QUARTER DATA
(MAR 88/JUN 88)

Category (Designator)	Frequency	Percent
General Unrestricted Line (1100,1105,1107)	28	14.2
Surface Warfare (1110,1115,1117)	62	31.4
Submarine Warfare (1120,1125)	14	7.1
Special Operations (1140)	1	0.5
Naval Aviation (1310,1311,1320)	31	15.7
Restricted Line (1460,1465,1510, 1520,1610,1630,1800)	32	16.2
Supply Corps (3100,3107)	27	13.7
Civil Engineering Corps (5100, 5105)	2	1.0
TOTAL	197	99.8

Table 10 shows the breakout of students by NPS curriculum.

TABLE 10

CURRICULUM ASSIGNMENT--SIXTH-QUARTER DATA
(MAR 88/JUN 88)

Curriculum Number	Curriculum	Frequency	Percent
837	Financial Management	25	12.7
367	Computer Systems Management	18	9.1
360	Operations Analysis	17	8.6
570	Naval (Mechanical) Engineering	17	8.6
368	Computer Science	14	7.1
815	Acquisition and Contract Management	11	5.6
373	Air-Ocean Science	10	5.1
525	Antisubmarine Warfare Systems	8	4.1
847	Manpower, Personnel and Training Analysis	8	4.1
530	Weapons Systems Engineering	7	3.6
590	Electronic Systems Engineering	6	3.0
366	Space Systems Operations	5	2.5

TABLE 10 (CONTINUED)

Curriculum Number	Curriculum	Frequency	Percent
591	Space Systems Engineering	5	2.5
687	NSA--Nuclear Strategic Planning	5	2.5
610	Aeronautical Engineering	4	2.0
827	Material Logistics Support Management	4	2.0
361	Operational Logistics	3	1.5
365	Joint Command, Control and Communications	3	1.5
814	Transportation Management	3	1.5
819	Systems Inventory Management	3	1.5
825	Intelligence	3	1.5
531	Weapon Systems Science (Physics)	2	1.0
535	Underwater Acoustics	2	1.0
611	Aeronautical Engineering--Avionics	2	1.0
681	NSA--Middle East, Africa, South Asia	2	1.0
374	Operational Oceanography	1	0.5
532	Nuclear Physics (Weapons and Effects)	1	0.5
595	Electronic Warfare Systems Engineering	1	0.5
600	Communications Engineering	1	0.5
620	Telecommunications Systems Management	1	0.5
682	NSA--Far East, Southeast Asia, Pacific	1	0.5
684	NSA--International Organizations and Negotiation	1	0.5
685	NSA--Western Hemisphere	1	0.5
686	NSA--General Strategic Planning	1	0.5
813	Transportation Logistics Management	1	0.5

B. COMPARATIVE STATISTICS

This section opens by comparing in Table 11 the various mean values for the continuous variables and percentages for

selected discrete variables in this study and the Transki study. [Ref. 9:pp. 17-20]

TABLE 11

COMPARATIVE VARIABLES TABLE--SIXTH-QUARTER DATA

Variable	This Study (MAR 88/JUN 88)	Transki Study (DEC 87)
N	197	198
Division Data:		
% DIV 05	61.7	62.9
% DIV 06	37.9	36.7
Sex:		
% Male	81.7	80.8
% Female	18.3	19.2
Rank:		
% Lieutenant (jun. grade)	.5	1.0
% Lieutenant	20.3	71.2
% Lieutenant Commander	76.6	27.8
% Commander	2.5	0
Age	30.99	31.05
T	7.79	7.65
VB	549.64	545.46
QT	629.09	627.42
AN	573.76	588.38
APC1	1.94	1.89
APC2	2.18	2.41
APC3	3.24	3.27
ZQPR	3.52	3.48

NOTE: Some percentages may not add up to 100 due to rounding.

The values of all the variables are very similar except for their military rank. This study shows the majority (76.6%) of the students in the sample to be Lieutenant Commanders, while the majority (71.2%) of the students in the Transki study are Lieutenants.

1. Correlation

Because of CNO tasking to the Naval Postgraduate School to determine "the necessary correlations between various possible predictors and performance" [Ref. 6], simple correlations were calculated using the Pearson correlation function of SAS. The stronger the relationship between the variable and ZQPR, the larger the correlation coefficient.

Correlations were computed for all sixth-quarter student data. They were also independently computed for the two NPS divisions--Division 05, the Policy and Information Sciences Division, and Division 06, the Sciences and Engineering Division. Appendix B lists the separate divisions with breakouts by department and curriculum. Appendix C shows the correlation table (Table 19) for all sixth-quarter student data, Appendix D (Table 20), Division 05 sixth-quarter data and Appendix E (Table 21), Division 06 sixth-quarter data.

Tables 12-14 compare these data with the December 1987 sixth-quarter data of the Transki findings. Note that the lower the Academic Profile Code, the better the student's undergraduate qualifications. We should, therefore, expect negative correlations with ZQPR in the following tables. [Ref. 9:pp. 22-25]

a. All Sixth-Quarter Data

TABLE 12

COMPARATIVE CORRELATION TABLE--ALL SIXTH-QUARTER DATA

Variable	This Study ZQPR	Transki Study ZQPR
AGE	-.153 .016 197	-.244 .000 198
T	-.036 .310 193	-.096 .094 189
VB	.401 .000 197	.311 .000 198
QT	.458 .000 197	.424 .000 198
AN	.460 .000 197	.350 .000 198
APC1	-.301 .000 196	-.348 .000 194
APC2	-.245 .000 196	-.108 .067 194
APC3	-.287 .000 196	-.121 .046 194

Pearson Correlation Coefficient
One-tailed Significance Level, p-value
Number of Observations

AGE (Age at Time of Exam)--Both this study and the Transki study findings are negatively correlated but the more recent group has a smaller correlation coefficient. The new group is significant only at the .05 level, while the Transki findings are significant at the .000 level.

TABLE 12 (CONTINUED)

T (Time Since Undergraduate Degree)--Both findings are negatively correlated, have similar magnitudes of correlation coefficient but are not significant at the .05 level.

VB (GRE Verbal Score)--Both findings are positively correlated with similar magnitudes of correlation coefficient. Both are significant at the .000 level.

QT (GRE Quantitative Score)--Both findings are positively correlated with similar correlation coefficients. Both are significant at the .000 level.

AN (GRE Analytical Score)--Both findings are positively correlated but the new group has a larger correlation coefficient. Both are significant at the .000 level.

APC1 (QPR Code of Academic Profile Code)--Both findings are negatively correlated and have similar magnitudes of correlation coefficient. Both are significant at the .000 level.

APC2 (Math Code of Academic Profile Code)--Both findings are negatively correlated. But the new group has a larger correlation coefficient and is significant at the .000 level, while the previous findings were significant at only the .1 level.

APC3 (Science/Technical Code of Academic Profile Code)--Both findings are negatively correlated. Again the new group has a larger correlation coefficient and is significant at the .000 level, while the previous findings are significant at only the .05 level.

b. Policy and Information Sciences Division (05)

TABLE 13

COMPARATIVE CORRELATION TABLE--DIVISION 05
SIXTH-QUARTER DATA

Variable	This Study ZQPR	Transki Study ZQPR
AGE	-.126	-.178
	.083	.019
	122	135
T	.013	-.049
	.444	.292
	119	129
VB	.441	.341
	.000	.000
	122	135
QT	.483	.438
	.000	.000
	122	135
AN	.517	.335
	.000	.000
	122	135
APC1	-.290	-.431
	.001	.000
	121	131
APC2	-.250	-.160
	.003	.034
	121	131
APC3	-.256	-.170
	.003	.026
	121	131

Pearson Correlation Coefficient
One-tailed Significance Level, p-value
Number of Observations

TABLE 13 (CONTINUED)

AGE (Age at Time of Exam)--Both this study and the Transki study findings are negatively correlated and roughly the same magnitude of correlation coefficient. The new findings are significant at only the .1 level, while the previous findings show a .05 level of significance.

T (Time Since Undergraduate Degree)--In the new findings, the correlation coefficients are slightly positive, while the Transki findings are slightly negative. However, neither finding is significant at even the .1 level.

VB (GRE Verbal Score)--Both findings are positively correlated, but the new group has a larger correlation coefficient. Both are significant at the .000 level.

QT (GRE Quantitative Score)--Both findings are positively correlated with roughly the same magnitude of correlation coefficient. Both are significant at the .000 level.

AN (GRE Analytical Score)--Both findings are positively correlated, but the new group has a larger correlation coefficient. Both are significant at the .000 level.

APC1 (QPR Code of Academic Profile Code)--Both findings are negatively correlated, but the Transki group has a larger correlation coefficient. Both are significant--the new group at the .001 level and the previous study at the .000 level.

APC2 (Math Code of Academic Profile Code)--Both findings are negatively correlated, but the new group has a larger correlation coefficient than the Transki group. Both findings are significant--the new group at the .005 level and the Transki study at the .05 level.

APC3 (Science/Technical Code of Academic Profile Code)--Both findings are negative, but the correlation coefficient of the new group is twice that of the Transki study. Both findings are significant--the new findings at the .005 level and the previous findings at the .05 level.

c. Sciences and Engineering Division (06)

TABLE 14

COMPARATIVE CORRELATION TABLE--DIVISION 06
SIXTH-QUARTER DATA

Variable	This Study ZQPR	Transki Study ZQPR
AGE	-.188	-.348
	.054	.003
	75	63
T	-.089	-.170
	.226	.097
	74	60
VB	.339	.286
	.002	.011
	75	63
QT	.452	.594
	.000	.000
	75	63
AN	.379	.384
	.001	.001
	75	63
APC1	-.313	-.263
	.003	.019
	75	63
APC2	-.271	-.160
	.010	.105
	75	63
APC3	-.385	-.167
	.001	.095
	75	63

Pearson Correlation Coefficient
One-tailed Significance Level, p-value
Number of Observations

TABLE 14 (CONTINUED)

AGE (Age at Time of Exam)--Both findings are negatively correlated, but the correlation coefficient for this study is smaller than that of the previous study. The new findings are significant at the 10% level, while the findings of the Transki study are significant at the .005 level.

T (Time Since Undergraduate Degree)--Both findings are negatively correlated, but the correlation coefficient for this study is almost half that of the previous study. The new findings are not significant at even the .1 level, while the Transki findings are significant at only the .1 level.

VB (GRE Verbal Score)--Both findings are positively correlated, but the new group has a larger correlation coefficient. Both findings are significant--the new group at the .005 level and the Transki group at the .05 level.

QT (GRE Quantitative Score)--Both findings are positively correlated, but this time the new group has a smaller correlation coefficient. Both groups are significant at the .000 level.

AN (GRE Analytical Score)--Both findings are positively correlated with similar magnitudes of correlation coefficient. Both are significant at the .001 level.

APC1 (QPR Code of Academic Profile Code)--Both findings are negatively correlated with roughly the same magnitude of correlation coefficient. Both are significant--the new group at the .01 level and the Transki group at the .05 level.

APC2 (Math Code of Academic Profile Code)--Both findings are negatively correlated, but the correlation coefficient of the new group is larger than that of the Transki study. The new findings are significant at the .001 level, while the previous findings are not significant at even the .1 level.

APC3 (Science/Technical Code of Academic Profile Code)--Both findings are negatively correlated, but the correlation coefficient of the new group is twice that of the previous study. Both findings are significant--this study at the .001 level and the Transki study at only the .1 level.

Table 15 shows in a combined table the comparative correlations of the predictor variables and ZQPR for this study and the Transki study. [Ref. 9:p. 26]

These findings validate those of the Transki study with regard to the usefulness of Graduate Record Examination scores and APC1 in predicting success at the Naval Postgraduate School. However, this study also found APC2 and APC3 to be quite powerful in predicting success. These findings showed AGE to be less significant (5% level) a factor in prediction than those of the Transki study (.000 level). This may possibly be due to the disparate rank structure of the two groups. The new group was primarily composed of Lieutenant Commanders (76.6%), while the Transki group was predominantly composed of Lieutenants (71.2%). Age differences between the two groups were negligible--average age of the new more senior group was 30.99 years, while the average age of the Transki group was 31.05 years.

Overall however these results confirm most of the major findings of the Transki study. Most importantly they validate the use of the GRE as a powerful and superior tool in predicting student success at the Naval Postgraduate School. In fact, the results of the above correlations in both studies show the Graduate Record Examination to be a much stronger predictor than the currently used Academic Profile Code.

TABLE 15

COMPARATIVE COMBINED CORRELATION TABLE

		Other		GRE			APC		
		AGE	T	VB	QT	AN	1	2	3
All Sixth-Quarter	This Study	-.153*	-.036	.401***	.458***	.460***	-.301***	-.245***	-.287**
	Transki Study	-.244***	-.096	.311***	.424***	.350***	-.348***	-.108	-.121*
Division 05	This Study	-.126	.013	.441***	.483***	.517***	-.290**	-.250*	-.256**
	Transki Study	-.178*	-.049	.341***	.438***	.335***	-.431***	-.160*	-.170*
Division 06	This Study	-.188	-.089	.338**	.452***	.379**	-.313**	-.271**	-.385**
	Transki Study	-.348**	-.170	.286*	.594***	.384**	-.263*	-.160	-.167

Correlation Coefficients for possible predictor variables and ZPQR

*** One-tailed Significance level = .000
** One-tailed Significance level = .01
* One-tailed Significance level = .05

2. Regression

Using SAS, regressions were run to discover how much of the variance of a predicted Graduate Quality Point Rating (QPR*) could be explained by the chosen variables and to develop an equation to predict academic success at the Naval Postgraduate School. [Ref. 9:p. 24]

Four sequences of regressions were run against ZQPR. First to see how well the Academic Profile Code predicted QPR*, then to see how well the GRE scores predicted it. A third regression was performed using both Academic Profile Code and Graduate Record Examination scores as predictors of QPR*. And lastly, the Transki-selected variables (APC1, GRE and AGE) were used to form a regression equation as a final measure for comparison with that study. [Ref. 9:p. 26]

The hypothesis remained the same in this study as in the previous one,

> ...that R^2 and $\bar{R}^2$ would both increase with successive equations, while the confidence interval around the estimate would decrease. It is understood that R^2 will always increase with the addition of new variables. $\bar{R}^2$, which is R^2 adjusted for degrees of freedom, will increase only if the new variable contributes to the equation. [Ref. 9:p. 26]

The outcome of these regression equations is displayed in comparative format with the results of the Transki equations in Tables 16-18. [Ref. 9:pp. 26,29,30]

a. All Sixth-Quarter Data

TABLE 16

COMPARATIVE REGRESSION RESULTS--
ALL SIXTH-QUARTER DATA

Variables		R^2	$\bar{R}^2$	SE
Academic Profile Code (APC1,APC2,APC3)	This Study	.156	.142	.345
	Transki Study	.129	.115	.277
Graduate Record Examination (VB,QT,AN)	This Study	.296	.285	.315
	Transki Study	.223	.211	.216
APC and GRE Combined (APC1,APC2,APC3,VB, QT,AN)	This Study	.346	.324	.307
	Transki Study	.276	.253	.254
Selected Variables from Transki Study (APC1,VB,QT,AN,AGE)	This Study	.328	.310	.310
	Transki Study	.289	.270	.252

Source: Based on [Ref. 9:p. 26]

In this study the Academic Profile Code by itself accounts for just 16% of the variance in predicted QPR (QPR*). This is slightly larger than the 13% variance predicted by the Academic Profile Code in the Transki study.

Also larger than in the Transki results is the predictive power of the Graduate Record Examination scores. GRE scores in this study predict 30% of the variance in QPR* while in the previous study their predictive power was only 22%.

However when the Academic Profile Code and GRE scores are combined, their predictive power increases to a

full 35% in this study compared with only 28% in the Transki study. With the addition of three variables to the regression equation, $\bar{R}^2$ increases in both studies.

By combining in one equation the variables selected in the Transki study as the best predictors (APC1, VB, QT, AN, AGE), the predictive value of the equation declines slightly in this study (by 2%) to 33%. $\bar{R}^2$ also declines. This contrasts with the results of the Transki study which show, as expected, continuing increases in R^2 and $\bar{R}^2$ over the three previous equations.

Continuing throughout this analysis to follow the format of the Transki study, forecast intervals were then calculated based on Equation (4.1).

$$FI = \hat{y}_{T+1} \pm S_F t_C \qquad (4.1)$$

[Ref. 15:p. 377]

This can be read as "the forecast interval equals the forecast plus or minus the estimated standard error of the forecast times the critical t-value," where

FI = the forecast interval,

$\hat{y}_{T+1}$ = the forecast,

S_F = the estimated standard error of the forecast,

t_C = the critical t-value (95% level of confidence). [Ref. 9:p. 27]

In using this equation two assumptions have been made. First is that the sample size (approximately 200) is sufficiently large that the variability of the regression coefficients can be ignored. Second is that in conjunction with the first assumption, the values of the input variables are close to the population average. Therefore, it should be noted that the forecast interval boundaries for an individual Naval Postgraduate School candidate may have length greater than that determined by the equation. [Ref. 15:p. 378] With this in mind, Figure 1 was calculated using the above equation for all sixth-quarter data in this study, where

$\hat{y}_{T+1}$ = 3.52 (the mean ZQPR for all equations),

S_F = varies (the SE for each regression in Table 19),

t_c = 1.96 (in this case, a two-sided 95% level of confidence). [Ref. 9:p. 27]

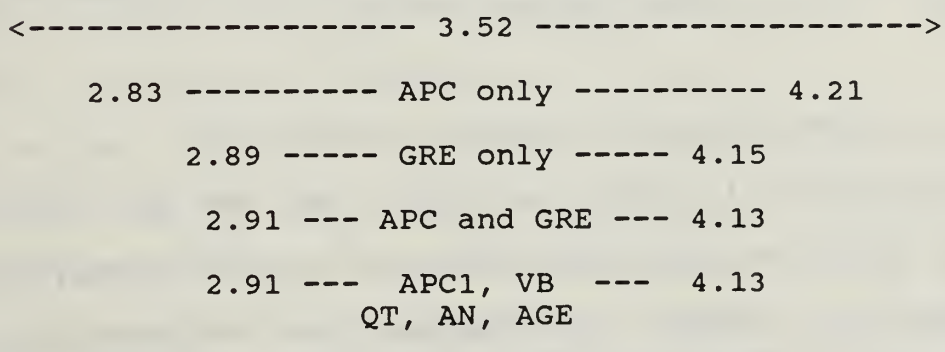

Figure 1. Forecast Intervals--All Sixth-Quarter Data (This Study)

Note that the intervals narrow until APC and GRE are combined. At this point the equation intervals stop narrowing and remain the same for the equation with APC1, VB, QT, AN and AGE. This would indicate "when combined with the good results of the regressions" [Ref. 9:p. 27] that the combination of APC and GRE scores is the best predictor of success at the Naval Postgraduate School.

This contrasts with the forecast interval findings of the Transki study shown in Figure 2. [Ref. 9:p. 28]

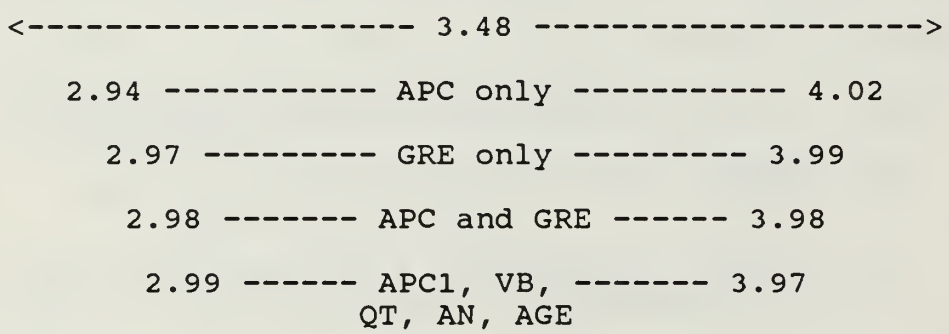

Figure 2. Forecast Intervals--All Sixth-Quarter Data (Transki Study)

Here forecast intervals continue to narrow to the last equation in which APC1, VB, QT, AN and AGE are combined. This is consistent with the Transki correlation and regression results on December 1987 sixth-quarter students, but is not confirmed by the more recent combined analysis of the March 1988 and June 1988 students in this study. This is not surprising based on the correlation and

regression results of the new group shown previously in Tables 15 and 16.

This study therefore supports a slightly different regression equation than supported by the previous study for selection boards to use in identifying students with potential for success at the Naval Postgraduate School. The new equation combines both Academic Profile Code measures and Graduate Record Examination scores as the strongest measure of potential NPS success. (See Equation (4.2) below.)

$$QPR^* = 2.4788 - .0669(APC1) + .0228(APC2) - .0461(APC3) + .0007(VB) + .0007(QT) + .0008(AN) \qquad (4.2)$$

> The results will yield QPR*--a forecast of the officer's graduate QPR at the Naval Postgraduate School. QPR* will still be a standardized value. If a potential student's curriculum is known, QPR* can be multiplied by the appropriate department factor.... [Ref. 9:p. 27]

Table 5 shows department standardizing factors. Appendix B lists curricula by department and division.

Following the Transki format, but with modifications to fit the new regression equation of this study, the selection process is demonstrated in the following case.

> ...assume Lieutenant Junior Grade GRAD is being considered for graduate education....He graduated from American University with a 3.00 grade point average. His Graduate Record Examination scores are 550 verbal, 600 quantitative and 580 analytical. He is interested in studying in the 681, 847 or 532 curricula." [Ref. 9:p. 27]

He has had two calculus courses with a C+ average and a complete calculus-based physics sequence with the same C+ average.

Using Equation (4.2), the selection board would calculate his potential NPS graduate QPR to be 3.5213. See Equation (4.3).

$$\begin{aligned} QPR^* &= 2.4788 - .0669(2) + .0228(2) - .0461(3) \\ &\quad + .0007(550) + .0007(600) + .0008(580) \\ &= 3.5213 \end{aligned} \tag{4.3}$$

Using department standardizing factors, Lieutenant Junior Grade GRAD's predicted Graduate QPR can now be adapted for each of the three curricula he is interested in. [Ref. 9:p. 28]

National Security Affairs

Curriculum 681: adjusted QPR* = 3.5213(1.069) = 3.76

Manpower, Personnel & Training Analysis

Curriculum 847: adjusted QPR* = 3.5213(.983) = 3.46

Physics (Weapons Systems Science)

Curriculum 531: adjusted QPR* = 3.5213(.963) = 3.39

Now by calculating a forecast interval around the adjusted Graduate QPR*s for each curriculum, the selection board should be able to predict with 95%

confidence that Lieutenant Junior Grade GRAD's Graduate QPR will fall within the computed range. [Ref. 9:p. 28]

Curriculum 681:	3.76	(.307)1.96	or	3.16	<----> 4.36
Curriculum 847:	3.46	(.307)1.96	or	2.86	<----> 4.06
Curriculum 531:	3.39	(.307)1.96	or	2.79	<----> 3.99

Knowing that to satisfy the requirements for a Master's Degree at the Naval Postgraduate School, a student must attain "a quality point rating of at least 3.00 in all graduate courses in the curriculum, and either 2.50 in the remaining courses or 2.75 in all courses in the curriculum" [Ref. 12:p. 7], it would seem that Lieutenant Junior Grade GRAD "may not be as good a risk in the physics curriculum as in national security affairs, or even in manpower, personnel and training analysis." [Ref. 9:p. 28]

Though the regression equation used to calculate QPR* and the corresponding forecast intervals for each curriculum is different from that of the Transki study, the relative selection results are the same. Lieutenant Junior Grade GRAD is a better risk in curriculum 681 than in curriculum 847 or in curriculum 531.

b. Policy and Information Sciences Division (05)

The same methodology was used to calculate regressions and forecast intervals for Division 05 data as was used above on all sixth-quarter data.

Table 17 compares the Division 05 results of this study with the regression equation results for Division 05 of the Transki study.

TABLE 17

COMPARATIVE REGRESSION RESULTS--DIVISION 05
SIXTH-QUARTER DATA

Variables		R^2	$\bar{R}^2$	SE
Academic Profile Code (APC1,APC2,APC3)	This Study	.162	.140	.336
	Transki Study	.203	.185	.217
Graduate Record Examination (VB,QT,AN)	This Study	.376	.359	.290
	Transki Study	.241	.224	.212
APC and GRE Combined (APC1,APC2,APC3,VB, QT,AN)	This Study	.414	.383	.285
	Transki Study	.309	.276	.204
Selected Variables from Transki Study (APC1,VB,QT,AN,AGE)	This Study	.394	.367	.288
	Transki Study	.312	.285	.203

Source: Based on [Ref. 9:p. 29]

In this study the Academic Profile Code by itself accounts for just 16% of the variance in predicted QPR (QPR*). This is smaller than the 20% variance predicted by the Academic Profile Code in the Transki study.

Also larger than in the Transki results is the predictive power of the Graduate Record Examination scores. GRE scores in this study predict 38% of the variance in QPR*, while in the previous study their predictive power was only 24%.

However, when the Academic Profile Code and GRE scores are combined, their predictive power increases to a full 41% in this study and 31% in the Transki study. Despite the addition of three variables to the regression equation $\bar{R}^2$ increases in both studies.

By combining in one equation the variables selected in the Transki study as the best predictors (APC1, VB, QT, AN, AGE), the predictive value of the equation declines, as it did when using all sixth-quarter data, by 2% from 41% to 39%. $\bar{R}^2$ also declines. This contrasts with the results of the Transki study which showed, as expected, continuing increases in R^2 and $\bar{R}^2$ over the three previous equations.

Forecast intervals were also developed for Division 05 data. They are shown in Figure 3. They are calculated based on the Division 05 mean ZQPR of 3.51.

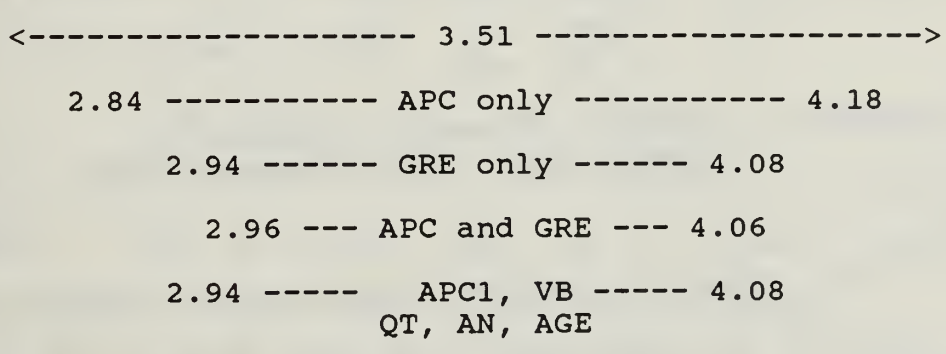

Figure 3. Forecast Intervals--Division 05 Sixth-Quarter Data (This Study)

These results support this study's choice of the regression equation which combines the APC and GRE scores as the best prediction tool. Notice that the confidence intervals continue to narrow until the final equation which uses the variables selected in the previous study. Here the confidence interval expands to the width of the equation using GRE scores alone. This indicates a weakening in the predictive power of the final equation for students in the Policy and Information Sciences Division.

This contrasts with the forecast interval findings of the Transki study shown in Figure 4. [Ref. 9:p. 29]

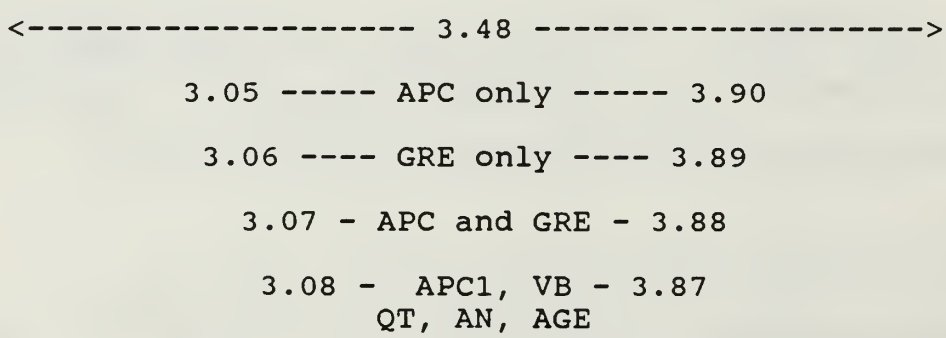

Figure 4. Forecast Intervals--Division 05 Sixth-Quarter Data (Transki Study)

Here forecast intervals continue to narrow to the last equation in which APC1, VB, QT, AN and AGE are combined. This is consistent with the regression results obtained on the total sixth-quarter data of that previous

study, but is not confirmed by the more recent data of this study.

The regression equation developed from this new data is useful for selection boards considering students for entry into any Policy and Information Sciences Division 05 curricula. It is shown in Equation (4.4) below.

$$QPR^* = 2.2636 - .0634(APC1) + .0297(APC2) - .0514(APC3) + .0007(VB) + .0009(QT) + .0009(AN) \qquad (4.4)$$

c. Sciences and Engineering Division (06)

The same method was used to calculate regressions and forecast intervals for Division 06 data as was used above on Division 05 sixth-quarter data and prior to that on all sixth-quarter data.

Table 18 compares the Division 06 results of this study with the regression equation results for Division 06 of the Transki study.

In this study the Academic Profile Code by itself accounts for 19% of the variance in predicted QPR (QPR*). This is larger than the 9% variance predicted by the Academic Profile Code in the Transki study.

However, the predictive power of the Graduate Record Examination scores alone, although increasing from that of the APC equation, is smaller in this study than in the Transki study. GRE scores in this study predict 21% of

TABLE 18

COMPARATIVE REGRESSION RESULTS--DIVISION 06
SIXTH-QUARTER DATA

Variables		R^2	$\overline{R^2}$	SE
Academic Profile Code (APC1,APC2,APC3)	This Study	.190	.156	.360
	Transki Study	.091	.044	.376
Graduate Record Examination (VB,QT,AN)	This Study	.213	.180	.354
	Transki Study	.355	.322	.317
APC and GRE Combined (APC1,APC2,APC3,VB, QT,AN)	This Study	.326	.266	.335
	Transki Study	.374	.307	.320
Selected Variables from Transki Study (APC1,VB,QT,AN,AGE)	This Study	.279	.226	.344
	Transki Study	.444	.395	.299

Source: Based on [Ref. 9:p. 30]

the variance in QPR*, while in the previous study their predictive power was 35%.

In the next regression, wherein the Academic Profile Code and GRE scores are combined, the predictive power of the equation continues to increase for both studies--to 33% in this study and 37% in the Transki study. Again despite the addition of three variables to the regression equation $\overline{R}^2$ increases in this study but declined in the Transki study.

By combining in one equation the variables selected in the Transki study as the best predictors (APC1, VB, QT, AN, AGE), the predictive value of the equation declines as it did when using all sixth-quarter data and Division 05 data. This time it declines 5% from 33% to 28%.

$\bar{R}^2$ also declines. This contrasts with the results of the Transki study which showed, as expected, increases in R^2 and $\bar{R}^2$ over the three previous equations.

Forecast intervals were also developed for Division 06 data. They are shown in Figure 5. They are calculated based on the Division 06 mean ZQPR of 3.54.

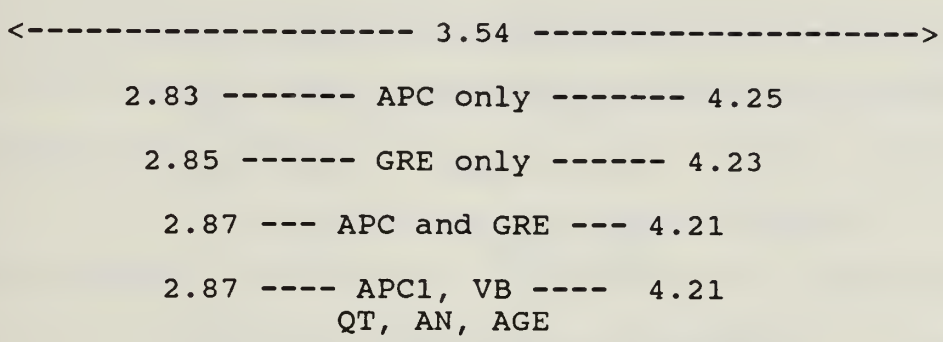

Figure 5. Forecast Intervals--Division 06 Sixth-Quarter Data (This Study)

These results support this study's choice of the regression equation which combines the APC and GRE scores as the best prediction tool. Notice that the confidence intervals continue to narrow until APC and GRE are combined. At this point the equation intervals stop narrowing and remain static for the equation with the Transki selected variables of APC1, VB, QT, AN and AGE. This would tend to indicate when combined with the regression results of Table 18 that the combination of APC and GRE scores is the best predictor of success at the Naval Postgraduate School. The

equation with APC1, VB, QT, AN and AGE in this study add nothing to the predictive power of the previous equation.

This contrasts with the forecast interval findings of the Transki study shown in Figure 6. [Ref. 9:p. 30]

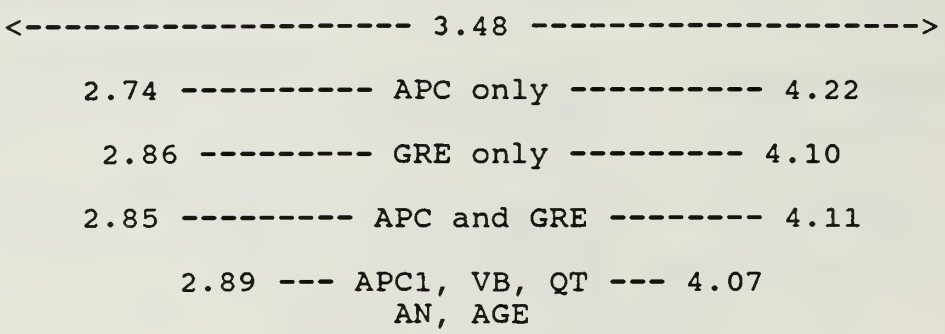

Figure 6. Forecast Intervals--Division 06 Sixth-Quarter Data (Transki Study)

Note the widening of the forecast interval where APC and GRE scores are combined. This is an anomaly in the Transki study where previously all forecast intervals have consistently narrowed from the first equation with APC alone until the final equation containing APC1, VB, QT, AN and AGE. It is not known why this is the case. Transki comments that the

> Forecast intervals for Division 06 are considerably wider than either the overall or Division 05 data....The wider intervals are due to larger standard errors in this sub-group. One possible explanation is the smaller number of cases in this sample combined with the different type of students. [Ref. 9:p. 30]

However, Figure 6 still shows the narrowest forecast interval to be around the final equation in which APC1, VB, QT, AN and AGE are combined. This is confirmed by the Table 18 regression results of the Transki study, but is not confirmed by the more recent results from the Division 06 data of this study.

The regression equation developed from the data in this study to select students desiring to enter curricula in the Sciences and Engineering Division is shown in Equation (4.5) below.

$$QPR^* = 2.6886 - .0451(APC1) - .0101(APC2) - .0790(APC3) + .0006(VB) + .0008(QT) - .0005(AN) \qquad (4.5)$$

d. Conclusion

Comparison of the regression results of this study with those of the Transki study was very much as expected from the earlier comparison of correlation coefficients between the two studies. The division results support the selection of the regression equation combining APC and GRE scores as the best measure for predicting academic success. R^2 is stronger in the Policy and Information Sciences Division (05) than in the regression results of the total sixth-quarter group, and even stronger, of course, than that in the Sciences and Engineering Division (06).

This contrasts with the Transki findings in which division regressions support the choice of APC1, VB, QT, AN and AGE as the best predictors of graduate school success. Here R^2 is stronger for both divisions than for the combined December 87 sixth-quarter data. R^2 is strongest for Division 06 in the Transki study. [Ref. 9:p. 31]

One possible explanation can be seen in Table 11. Although the descriptive statistics for both studies seem similar (almost identical) in many ways--the number of cases, the percentage of males and females, age, time since undergraduate degree, APC measures, GRE scores and even the percentage of cases in Division 05 and Division 06--the primary disparity between the two groups can be seen in the seniority of their members. The new group is predominantly composed of Lieutenant Commanders (76.6%), while the Transki group was principally composed of Lieutenants (71.2%).

Another explanation for the disparity between the findings of the two studies is based on the fact that while the forecasting ability of a multiple regression equation is rather good when applied to the data for which it was built, it performs below expectations when applied to new data. Therefore, because general processing conditions lack temporal stability from quarter to quarter, the results of the two studies would vary. [Ref. 16]

V. CONCLUSION

A. SUMMARY

In an effort to contribute to the body of knowledge associated with the Naval Postgraduate School's ongoing three-year study of the Graduate Record Examination, this thesis has been able to validate the results of a previous study during this time frame. Both this study and the previous one show the Graduate Record Examination to be a much stronger predictor of academic success at the Naval Postgraduate School than the currently used Academic Profile Code [Ref. 9:p. 37].

However, the results of this study show the best predictor of success to be the combination of the Graduate Record Examination and the Academic Profile Code. These findings provide compelling statistical support for the July 1985 views of the Provost, Naval Postgraduate School. In a memo dated 22 July he states that although "The GRE cannot replace the APC...the GRE will significantly enhance the selection process." [Ref. 4] The results backing this viewpoint are borne out time and again in the correlation and regression analysis of this research on both NPS division data as well as data from the entire school.

B. RECOMMENDATIONS

In view of these findings it is recommended that the Navy use the nationally recognized Graduate Record Examination in conjunction with the Academic Profile Code in its selection of officers to attend the Naval Postgraduate School.

This should be done using Equation (4.2) to calculate an officer's overall potential for success at NPS. [Ref. 9:p. 37]

$$QPR^* = 2.4788 - .0669(APC1) + .0228(APC2) - .0461(APC3) + .0007(VB) + .0007(QT) + .0008(AN) \quad (4.2)$$

where

QPR* = predicted graduate QPR,

APC1 = undergraduate QPR measure of the APC,

APC2 = undergraduate math measure of the APC,

APC3 = undergraduate technical/science measure of the APC,

VB = verbal score of the GRE,

QT = quantitative score of the GRE,

AN = analytical score of the GRE. [Ref. 9:p. 37]

Once an officer's potential for academic success has been computed and he or she has been selected to attend the Naval Postgraduate School, departmental factors (see Table

5) may be applied to more accurately assign individuals to the various curricula. [Ref. 9:p. 37]

Because both this study and the previous study show the GRE to be a much more powerful predictor of graduate school success than the APC by itself and because the Defense Activity for Non-Traditional Education Support (DANTES), not the Navy, will pay for the one-time administration of the GRE to military personnel [Ref. 8], it is further recommended that the GRE be required for all officer accessions indefinitely. If some of these officers continue their education at night, by correspondence, etc., and feel they can better their scores and hence chances for selection to the Naval Postgraduate School, they may retake the Graduate Record Examination at their own expense.

Given the above conditions and the strength of the GRE as a predictor of academic success, the Navy can only benefit by including the Graduate Record Examination in the selection criteria for admission to the Naval Postgraduate School; it cannot lose.

C. FURTHER RESEARCH

Areas for further research on the data which continue to be collected during this three-year test period (April 1986-April 1989) include the potential effect of rank, accession source, officer designator, undergraduate class standing and other descriptive variables on success at the Naval Postgraduate School.

It is also recommended, as observations are added to the database, that further research be conducted as part of a continuing refinement of selection equations and departmental weighting factors for the assignment of students to the most suitable curricula.

APPENDIX A

GRADUATE EDUCATION REVIEW GROUP/
GRADUATE EDUCATION REVIEW BOARD

Graduate Education Review Group
15 October 1984

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APPENDIX B

NPS CURRICULA--A BREAKOUT BY DEPARTMENT AND DIVISION*

05 Policy and Information Sciences Division
- 52 Computer Science Department
  - 367 Computer Systems Management
  - 368 Computer Science
- 53 Mathematics Department
  - 380 Advanced Science
- 54 Administrative Sciences Department
  - 813 Transportation Logistics Management
  - 814 Transportation Management
  - 815 Acquisition and Contract Management
  - 819 Systems Inventory Management
  - 827 Material Logistics Support Management
  - 837 Financial Management
  - 847 Manpower, Personnel and Training Analysis
  - 620 Telecommunications Systems Management
- 55 Operations Research Department
  - 360 Operations Analysis
  - 361 Operational Logistics
- 56 National Security Affairs Department
  - 681 Middle East, Africa, South Asia
  - 682 Far East, Southeast Asia, Pacific
  - 683 Europe, USSR
  - 684 International Organizations and Negotiations
  - 685 Western Hemisphere
  - 686 Strategic Planning--General
  - 687 Strategic Planning--Nuclear
  - 825 Intelligence

06 Sciences and Engineering Division
- 61 Physics Department
  - 530 Weapons Systems Engineering

531 Weapons Systems Science (Physics)
532 Nuclear Physics (Weapons and Effects)
535 Underwater Acoustics

62 Electrical and Computer Engineering Department
590 Electronic Systems Engineering
600 Communications Engineering

63 Meteorology Department
372 Meteorology
373 Air-Ocean Science

67 Aeronautics Department
610 Aeronautical Engineering
611 Aeronautical Engineering--Avionics

68 Oceanography Department
374 Operational Oceanography
440 Oceanography
441 Hydrographic Sciences

69 Mechanical Engineering Department
570 Naval (Mechanical) Engineering

71 Antisubmarine Warfare Academic Group
525 Antisubmarine Warfare Systems

72 Electronic Warfare Academic Group
595 Electronic Warfare Systems Engineering

73 Space Systems Academic Group
366 Space Systems Operations
591 Space Systems Engineering

74 Command, Control and Communications Academic Group
365 Joint Command, Control and Communication

*Data for breakout were obtained from the NPS Dean of Information and Policy Sciences list dated 2 May 1988.

TABLE 19

CORRELATION TABLE--ALL SIXTH-QUARTER DATA

	AGE	T	VB	QT	AN	APC1	APC2	APC3	ZQPR
AGE	1.000	0.755	0.029	-0.199	-0.175	0.008	0.166	0.255	-0.153
AGE AT TIME OF EXAM	0.000	0.000	0.341	0.003	0.007	0.453	0.010	0.000	0.016
(COMPUTED)	197	193	197	197	197	196	196	196	197
T		1.000	0.125	-0.125	-0.078	0.049	0.189	0.184	-0.036
TIME SINCE UDEGREE		0.000	0.042	0.042	0.140	0.251	0.004	0.006	0.310
AT TIME OF EXAM		193	193	193	193	193	193	193	193
(COMPUTED)									
VB			1.000	0.462	0.559	-0.260	-0.169	-0.036	0.401
GRE VERBAL SCORE			0.000	0.000	0.000	0.000	0.009	0.310	0.000
			197	197	197	196	196	196	197
QT				1.000	0.588	-0.200	-0.491	-0.416	0.458
GRE QUANTITATIVE				0.000	0.000	0.003	0.000	0.000	0.000
SCORE				197	197	196	196	196	197
AN					1.000	-0.256	-0.225	-0.148	0.460
GRE ANALYTICAL					0.000	0.000	0.001	0.019	0.000
SCORE					197	196	196	196	197
APC1						1.000	0.361	0.211	-0.301
QPR CODE OF ACADEMIC						0.000	0.000	0.002	0.000
PROFILE CODE						196	196	196	196
APC2							1.000	0.528	-0.245
MATH CODE OF ACADEMIC							0.000	0.000	0.000
PROFILE CODE							196	196	196
APC3								1.000	-0.287
SCIENCE CODE OF ACA-								0.000	0.000
DEMIC PROFILE CODE								196	196
ZQPR									1.000
STANDARDIZED GRADUATE									0.000
QPR FOR AY87									197

Pearson Correlation Coefficients; One-tailed Significance Level, p-value; Number of Observations

TABLE 20

CORRELATION TABLE--DIVISION 05 SIXTH-QUARTER DATA

	AGE	T	VB	QT	AN	APC1	APC2	APC3	ZPQR
AGE	1.000	0.765	0.009	-0.087	-0.123	-0.062	0.071	0.194	-0.126
AGE AT TIME OF EXAM (COMPUTED)	0.000 122	0.000 119	0.460 122	0.170 122	0.089 122	0.250 121	0.219 121	0.017 121	0.083 122
T		1.000	0.126	0.051	-0.022	0.001	0.076	0.063	0.013
TIME SINCE UDEGREE AT TIME OF EXAM (COMPUTED)		0.000 119	0.087 119	0.291 119	0.408 119	0.497 119	0.205 119	0.249 119	0.444 119
VB			1.000	0.407	0.588	-0.315	-0.222	-0.014	0.441
GRE VERBAL SCORE			0.000 122	0.000 122	0.000 122	0.000 121	0.008 121	0.439 121	0.000 122
QT				1.000	0.561	-0.156	-0.527	-0.377	0.483
GRE QUANTITATIVE SCORE				0.000 122	0.000 122	0.044 121	0.000 121	0.000 121	0.000 122
AN					1.000	-0.331	-0.277	-0.128	0.517
GRE ANALYTICAL SCORE					0.000 122	0.000 121	0.001 121	0.082 121	0.000 122
APC1						1.000	0.274	-0.019	-0.290
QPR CODE OF ACADEMIC PROFILE CODE						0.000 121	0.001 121	0.416 121	0.001 121
APC2							1.000	0.433	-0.250
MATH CODE OF ACADEMIC PROFILE CODE							0.000 121	0.000 121	0.003 121
APC3								1.000	-0.256
SCIENCE CODE OF ACADEMIC PROFILE CODE								0.000 121	0.003 121
ZQPR									1.000
STANDARDIZED GRADUATE QPR FOR AY87									0.000 122

Pearson Correlation Coefficients; One-tailed Significance Level, p-value; Number of Observations

TABLE 21

CORRELATION TABLE--DIVISION 06 SIXTH-QUARTER DATA

	AGE	T	VB	QT	AN	APC1	APC2	APC3	ZQPR
AGE	1.000	0.660	0.111	-0.172	-0.214	0.017	0.086	0.030	-0.188
AGE AT TIME OF EXAM	0.000	0.000	0.172	0.070	0.033	0.443	0.231	0.400	0.054
(COMPUTED)	75	74	75	75	75	75	75	75	75
T		1.000	0.215	-0.176	-0.112	0.028	0.116	-0.039	-0.089
TIME SINCE UDEGREE		0.000	0.033	0.067	0.172	0.408	0.162	0.371	0.226
AT TIME OF EXAM		74	74	74	74	74	74	74	74
(COMPUTED)									
VB			1.000	0.580	0.511	-0.175	-0.009	0.003	0.339
GRE VERBAL SCORE			0.000	0.000	0.000	0.066	0.471	0.492	0.002
			75	75	75	75	75	75	75
QT				1.000	0.651	-0.201	-0.193	-0.229	0.452
GRE QUANTITATIVE				0.000	0.000	0.042	0.049	0.024	0.000
SCORE				75	75	75	75	75	75
AN					1.000	-0.142	-0.063	-0.113	0.379
GRE ANALYTICAL					0.000	0.113	0.296	0.167	0.001
SCORE					75	75	75	75	75
APC1						1.000	0.544	0.435	-0.313
QPR CODE OF ACADEMIC						0.000	0.000	0.000	0.003
PROFILE CODE						75	75	75	75
APC2							1.000	0.521	-0.271
MATH CODE OF ACADEMIC							0.000	0.000	0.010
PROFILE CODE							75	75	75
APC3								1.000	-0.385
SCIENCE CODE OF ACA-								0.000	0.001
DEMIC PROFILE CODE								75	75
ZQPR									1.000
STANDARDIZED GRADUATE									0.000
QPR FOR AY87									75

Pearson Correlation Coefficient; One-tailed Significance Level, p-value; Number of Observations

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